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Review of the doctoral dissertation of MSc. Arianna Varrani on 'Onset of motion of compact-shaped microplastics in open-channel flows'

Msc. Varrani presents an experimental investigation dealing with the onset of motion of compact-shaped microplastics in open-channel flows. The overall theme of the thesis refers to critical environmental aspects with significant implications for eco-engineering applications. In general, Msc. Varrani investigates the microplastics' incipient motion and remobilisation in open channel flows by laboratory experiments using image analysis and acoustic velocimetry. The thesis is scientifically robust and innovative, and the work aligns well with contemporary research assessment criteria, with potential impact on environmental flows and engineering applications. I leave a few comments, which may seem extensive but this is due to my interest in the topic and the willingness to help the candidate to improve her thesis.

The manuscript, written in English, is well written. The organization is adequate, and the quality of figures and tables is of high quality. The document contains lists of figures, tables, acronyms and symbols. Its structure is adequate, and, besides the outline, it is divided into five sections of introduction, methodology, results and one of conclusions.

Specifically, the work is based on experimental data, presenting original findings within the domain of environmental fluid mechanics. The results are novel and of good quality, achieved through adequate laboratory techniques and complemented by pertinent data analysis and theoretical interpretation. The data generated from this research will serve as a valuable resource for the scientific and technical community.

The outline contextualizes the research in general terms and formulates the research questions addressed in this thesis.

Section 2 is devoted to the introduction. A detailed review on incipient motion studies for sediments is provided, followed by an overview on the few studies on microplastics remobilisation and incipient motion available in the literature.

Section 3 is focused on the methodology and two sets of experiments are described. In the first set of experiments the incipient motion of plastic particles from a loose plastic bed is investigated, referred to homogeneous bed experiments. In the second set of experiments, the remobilisation of compact microplastics from a natural clastic bed is studied, referred to clastic bed experiments. The experimental procedure together with the experimental measurements are described. In particular, two different UVPs (Ultrasound Velocity Profiles) are used to measure instantaneous velocity profiles and an image analysis technique is used to evaluate bed movements. Two different microplastic particles (PA6 and POM) are used characterized by different densities, size and shape of the particles.
I suggest to add more details on the UVPs systems used in this work, i.e. the Ubertone and the Signal Processing. The model of the UVPs has to be added together with two sketches of the set up used showing the top view (for homogeneous bed experiments) and the and the side view (for the clastic bed experiments) of the position of the transducers. The pictures shown in the appendix are not enough clear. In addition, details on the transducers used should be added. The screenshot shown in the appendix is not clear enough, I suggest to add a list of all the parameters used and shown in the screenshot for both the Ubertone's UVP and the Signal processing's UVP measurements (prf, emitting frequentcy, number of gates/cells, …). UVP transducers emit a signal with a divergence angle affecting the size of the measurement volumes, depending on the emitting frequency and the size of transducers. The divergence angle should be added in the thesis and the implication on the size of the measurements volumes has to be added. At page 39, the author writes: 'The cell size for each measurement was 0.91 mm long', but what is its maximum width for the cells used in the measurement? It should be mentioned for both the UVPs systems. In addition, the accuracy of the velocity measurements should be added.

Section 4 is devoted to the homogeneous bed experiments where the incipient motion of plastic particles from a loose plastic bed is investigated. Different experiments are performed by testing three flow conditions and two types of plastic bed. UVP velocity measurements are used to evaluate the time-averaged bed shear velocity and bed changes are measured by image analysis. Threshold conditions for bedload transport of plastic particles are evaluated and discussed.
At page 53, the author writes 'with spatial resolution for the velocity data of 1.1 - 1.5 mm' what do you mean by spatial resolution for velocity measurements? Is the distance between the centers of the gates/cells of each velocity profile? Also in this case, the acoustic beam divergence should be considered when defining a spatial resolution of the UVP measurements. A detailed definition of the spatial resolution should be added in the text.
At page 56, the author writes 'Such variability can be likely ascribed to near-bed turbulence, at frequencies much higher than 0.2 Hz'. There could be any effect of the size of the measurement volume of UVP?

Section 5 shows the clastic bed experiments, where the remobilisation of compact microplastics from a natural clastic bed is studied. In this set of experiments, the motion of the two microplastic particles (PA6 and POM) positioned over a natural sediment bed of sand and gravel is investigated. Five increasing concentrations of micro plastics content in the uppermost bed layer and three flow conditions are tested for each particle. UVP is used to measure vertical velocity profiles for the estimation of the bed shear velocity and bed changes are measured by image analysis. Threshold conditions on clastic bed are derived

and analyzed by the use of dimensional analysis. The results are discussed showing a negligible effect of the initial concentration of MPs and the important role of particle's submergence.
I suggest to add details on the UVP used for these measurements. At page 66, the author writes 'spatial resolution of 0.91 mm', is it the height of each gate? What is the gate's width? Again, information about the shape of the acoustic signal, i.e. divergence angle of the probe used, should be added.
At page 79, Figure 5.9 shows that the threshold value for PA6 on sand is much lower than previous studies and the author claims that it is due to the low water depth, i.e. low pressure, of these experiments compared to the literature. Why the water depth of PA6 on gravel does not exhibit a similar behavior? Discuss it in the text.

Section 6 deals with the main conclusions and the future development of this pioneering work. The conclusions are competent in summarizing the main findings and scope of the research.

The quality and rigor of this thesis align with the expectations for a dissertation at international research institutions, as recognized within the academic community.

The candidate's has an excellent general theoretical knowledge in the discipline and a very good ability to independently carry out scientific research.
Based on my knowledge and my comments above, I can claim that the solution of the problem in the doctoral dissertation is original.
My opinion regarding the candidate's admission to the public defense of the doctoral dissertation is positive.

Yours sincerely,

Claudia Adduce